Using Cognitive Task Analysis to Capture Expert Knowledge and Skills for Research and Instructional Design

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Workshop Objectives

During and after this workshop you will:

- Learn about the development of expertise, automated knowledge and self-report
- Learn about CTA and its effectiveness
- Watch an CTA demonstration
- Conduct a CTA with another person
- Show your CTA to the Workshop and discuss
- Collaborate to produce a gold standard CTA
- Learn about other knowledge required
- Learn how we pull CTAs into instructional design and research

Topics and Plan

Time	Topic and Activity
1:00 – 2:00	CTA Discussion and Q & A: Purpose, Methods, Benefits & Evidence
2:00 – 2:15	Break
2:15 – 3:00	CTA Demonstration Discussion and Q & A
3:00 – 3:45	CTA Practice Interviews
3:45 – 4:00	Break
4:00 – 4:30	CTA Results Discussion and Q & A
4:30 – 4:50	CTA and Instructional Design & Research Discussion and Q & A
4:50 – 5:00	Workshop Feedback Form

Cognitive Task Analysis (CTA)

Extends traditional task analysis to capture information about both the ***overt observable behavior*** and the ***covert cognitive functions*** behind it to form an integrated whole.

Schraagen, Chipman & Shalin, 2000

Why is CTA important?

Consequences of expertise

- 70% - 90% of knowledge is procedural, automated and non conscious
- Experts are unaware of how they make decisions so they leave out 70% of "how to do it" when teaching
  - Substitute "what to do" conceptual knowledge
  - Are sometimes wrong about "what to do"
- Meta analysis of the past 25 years of research indicates that the best instruction contributes only an average 20% increase in performance.
- Students must "construct how" with "trial and error" and become mentally overloaded
- Our mental capacity is limited to 3-4 items at once
  - If we exceed our limit, we "zone out" or give up

What is Cognitive Task Analysis?

- Interview strategy for capturing how highly successful people perform complex tasks
  - Emphasis on what they “don’t know they don’t’ know”
- Experts selected because they are consistently and recently (2-3 months) successful (not just experienced) and NOT instructors.
- Three to four experts interviewed and individual solution strategies are edited into one basic approach for novices based on maximum efficiency and accuracy
- Range of problem examples or performance scenarios are also collected from experts for use in instruction

Interview Three SMEs: One at a time

- Each expert tends to have a conscious awareness of different “when and how” information about decisions – and sometimes actions.

- Cross-checking with other SMEs increases accuracy and completeness by 50 % or more (from about 30% with 1 SME to about 70% or more with 3 SMEs).

Why is CTA important?

Types of Knowledge

- Declarative
  - Knowing “what”
  - Knowledge of concepts, principles and processes
  - Conscious, retrieval is slow and taxing
- Procedural
  - Knowing “how”
  - Includes cognitive skills, motor skills and cognitive strategies
  - Non-conscious, retrieval is quick and effortless

Why is CTA important?

Acquiring Expertise

- Cognitive Stage
  - Steps learned and edited
  - Correct steps automate
- Associative Stage
  - Chunks of steps automate
  - Sequence automates
  - Conscious cues decay
- Autonomous Stage
  - Repetition increases speed of execution
  - Loss of conscious access to steps and some chunks

What Evidence for Effectiveness?

Typically 30-50% learning gains with CTA-based instruction

- Patent examiners finish 75% faster (6 mo. Vs. 2 yrs.)
  - Production increase 200%+ mistakes down 65%
- Surgical residents finish 25% faster, learn 40% more
  - Important mistakes reduced 50%
- Tofel-Grehl (2011) 57 comparisons averaged 30% learning increase over control
  - Using Hedges' g (0.88) for conservative estimate

What problems will CTA not solve ?

IF:

- No experts available and/or
- Completely new (novel) equipment or
- New processes and policy or
- If “experts” not consistently succeeding at task

THEN: We use traditional analysis techniques but attempt to describe decisions and sequence as in CTA

How to select Subject Matter Experts for CTA?

1. Three to five years of consistently successful performance validated with objective evidence.
    - Avoid opinion in favor of “hard evidence of success”.
2. Recent (within 6 months) field performance of task
3. Broad experience performing in many different settings
4. Has NOT served as an instructor for the task

How is CTA performed? The Six Steps

1. Outline sequence tasks as performed on the job
2. Describe context, cue, actions and decisions
3. Collect information about equipment, standards, difficulty for novices, and reasons
4. Identify conceptual knowledge required
5. Collect field problems for demo, practice, testing
6. Correct and verify accuracy of the results

What is Cognitive Task Analysis? Six Steps

Interview 2 –3 experts with recent, successful experience

Step 1: Ask about sequence of tasks to perform job

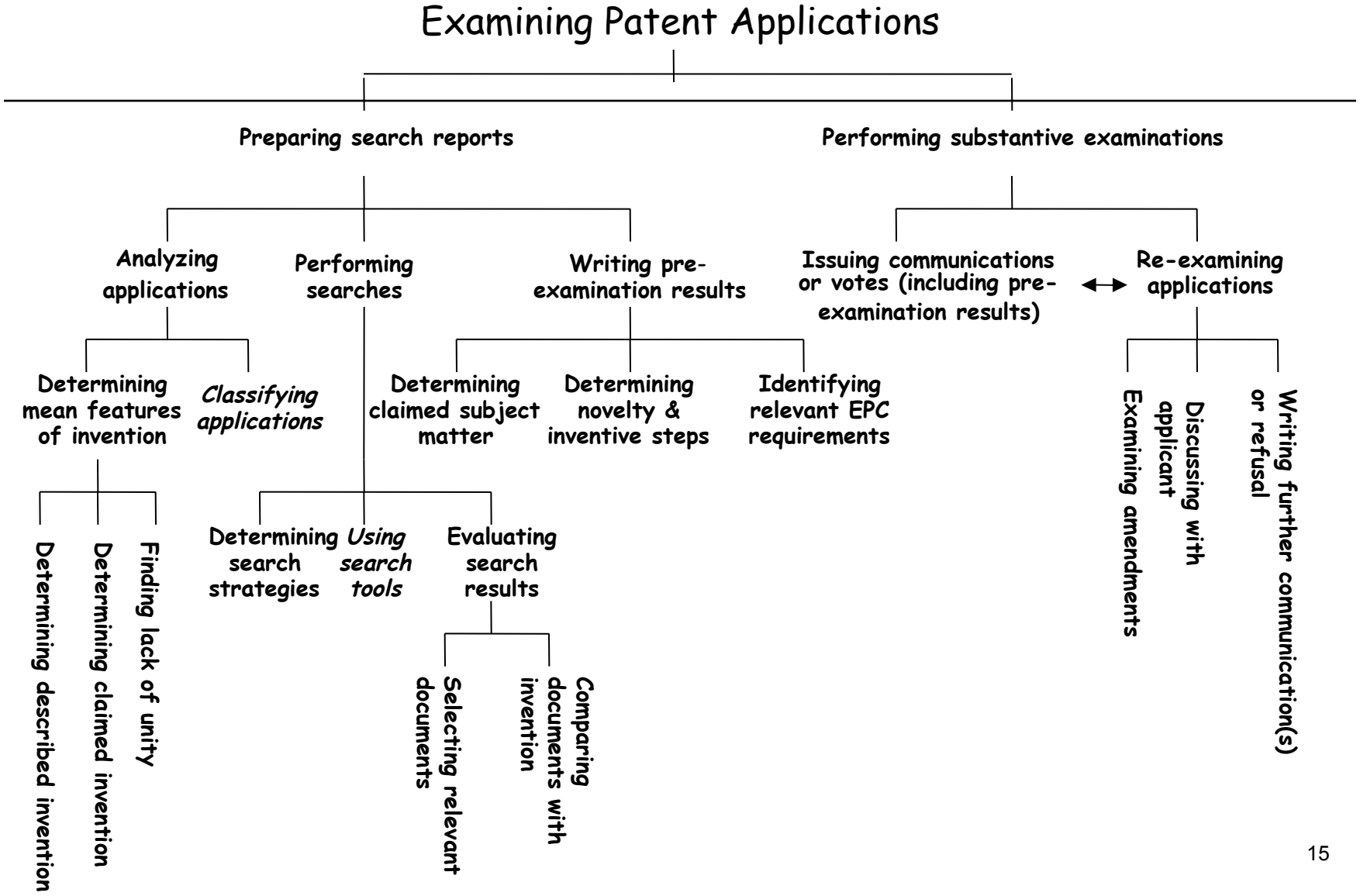
Outline main procedures “as performed on the job”

When no necessary sequence, then list easy to difficult

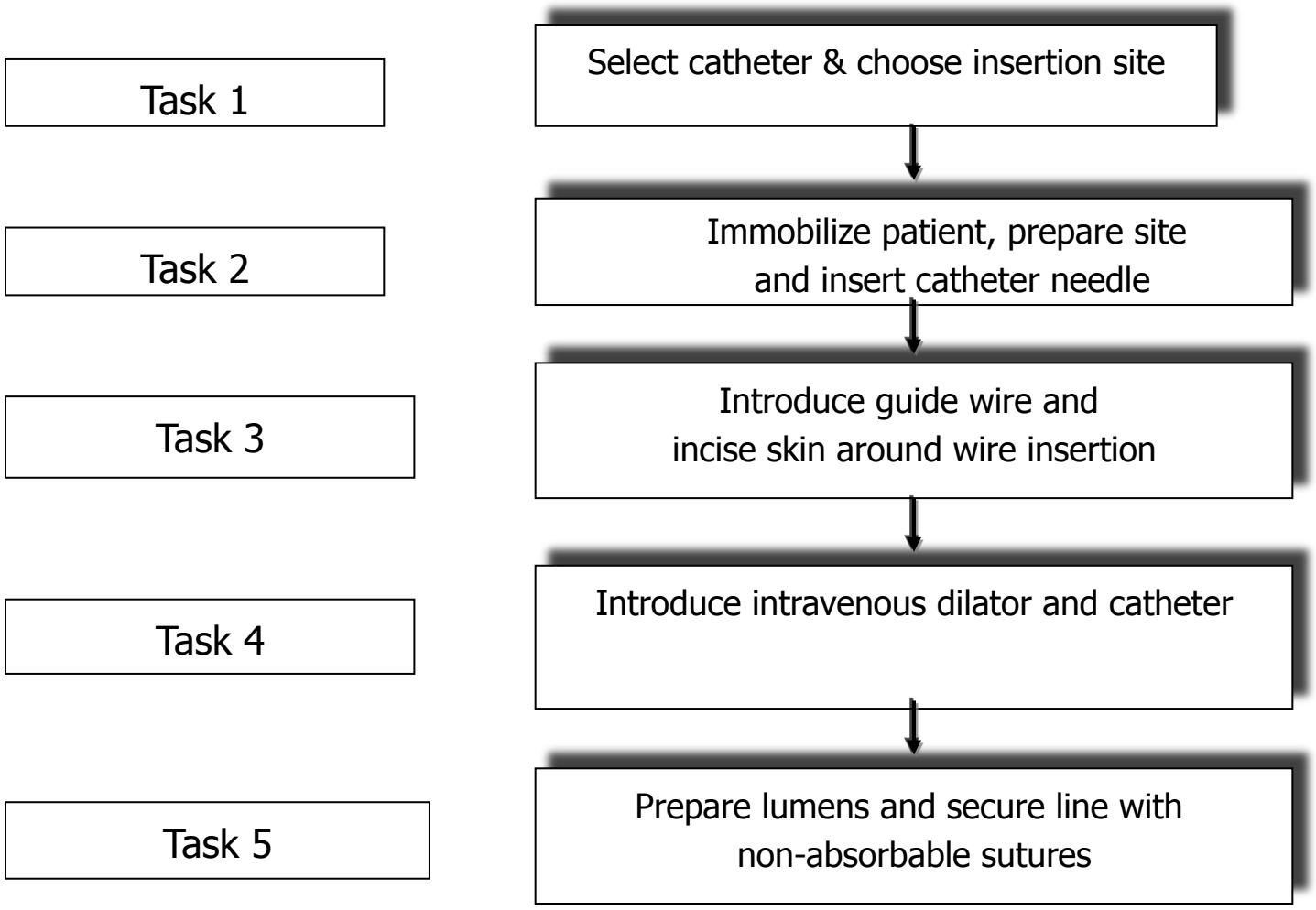
Identify tasks that are ‘prerequisite’ to other tasks

- Have expert approve the outline
- Delete tasks that do not close gaps

Sample CTA Outline



Surgery CTA example – Task Sequence



What is Cognitive Task Analysis? Six Steps

Step 2: Capture When and How steps

For each task, describe clearly enough so that trainees can read and apply

- Job context (Where is this task performed?)
- Cue (What starts the task?)
- Sequence of Actions and Decisions
  - What do you do next?
  - How do you make that decision?
- Actions are physical behaviors
  - Often result from decisions (note the verb)

Military CTA Example

Name of Procedure: Create and update sectors (Basic SITMAP)
Cue: BSNCO instructed to create SITMAP by Battle MAJ or Battle CPT

Step 1 (Action)	Log on to computer system. Load Map Man software application and toolbars (Drawing, Copy Machine, Edit mode, and Task Organization Chart) and Load the 2D map
Step 2: (Action)	Center map, zoom on section of interest, and set as a Preset Map View
Step 3: (Decision)	Receive printed map from Battle MAJ or CPT - Review the printed map and compare it with existing overlays in the CPOF IF you find a similar overlay, THEN drag it into Copy Machine IF you cannot find an overlay that is similar OR if you've dragged all similar overlays into the Copy Machine, THEN go to Step 4

Surgery CTA Example

Goal: Establish an easy route to infuse and monitor fluids in the venous system.

Conditions: *Indications:*

- Poor peripheral access
- Need for rapid resuscitation by infusion of fluids and blood
- Require long-term infusion of medications or irritating solutions
- Need central venous or pulmonary artery pressure monitoring
- Hemodialysis, plasmapheresis, extracorporeal life support, transvenous pacemakers

Contraindications: Trauma around site of insertion

- Infection in the site of insertion
- Venous thrombosis at the selected vein

Step 2: Decide among three sites for catheter placement

IF the neck is accessible and can be moved and the head and neck are free of excessive equipment, **THEN** select jugular placement

IF neck is inaccessible or cannot be moved, **THEN** select subclavian.

IF neck is inaccessible or immobile, the subclavian veins are thrombosed and there is not injury to the IVC, **THEN** select femoral vein placement

Advantage: Easy access, alternative if subclavian and jugular are ruled out, lowest rate of serious complications.

Disadvantage: Highest rate of infection, must be removed after 24 hours, possible loss of resuscitation fluid if concomitant IVC injury.

Break: 10 minutes

A brief demonstration…

Practice…

- Pair-up with another person
- Select a task
- One person is the expert; one is the interviewer
- Write down the steps for 10 minutes
- Reverse roles with another task for 10 minutes

We will compare the results from each interview.

Break: 10 minutes

What is Cognitive Task Analysis? Six Steps

Step 3

Collect task-related information about:

- Supplies and equipment (and location)
- Performance standards (speed, quality)
- Common novice performance errors
- Reasons (Personal Benefits and Personal Risks)

What is Cognitive Task Analysis? Six Steps

Step 4

Identify conceptual knowledge related to procedure:

- Concepts (define new terms – get examples)
- Processes (how things work)
- Principles (what causes things to happen)

Conceptual knowledge is important IF people must remember something to tell someone else about it – or if they must adjust a procedure to tackle a novel problem.

- Increases cost and time of instruction by +/- 30%

Knowledge Types in CTA for Design

Knowledge Type	Presentation	Practice/Assessment	
		Remember	Use
Procedure	List of steps, demonstration, problem that procedure will solve	Recognize, recall, or reorder the steps	Decide when to use; perform action and decision steps;
Concept	The definition, critical attributes, examples, non-examples	Recognize, recall, or explain the definition or attributes	Identify, classify, or create examples
Process/ System	Describe how something works in stages with transitions, diagrams, inputs, outputs, stories	Recognize, recall, explain, or reorder the stages	Identify origins of problems; troubleshoot to solve problems in the process
Principle	Describe cause and effect principle with examples, analogies, problems it solves.	Recognize, recall, or explain the principle	Decide if principle applies; predict an event; apply the principle to solve a problem or make decisions

Adopted from: Merrill, D. (1983). Component Display Theory. In C. M. Reigeluth (ed), *Instructional Design Theories and Models: An Overview of their Current States*. Hillsdale, NJ: Lawrence Erlbaum. Used by permission.

What is Cognitive Task Analysis? Six Steps

Step 5

Collect five field problems trainees will learn to solve

- One for demonstration during instruction
- One for practice and feedback
- One for progress check
- Two for competency tests

What is Cognitive Task Analysis? Six Steps

Step 6

Generate CTA report.

Ask SME to correct it.

Take CTA document from SME A and give to SME to "correct" and vice versa.

- Develop a "gold standard" CTA for instruction and/or job aid development – use language novices will understand.

Gold Standard: Avoiding IEDs

Step 3.1.: IF, at any point during the patrol, you identify a possible IED, THEN yell "Stop!".

Step 3.1.1.: IF you recognize a potential threat situation, THEN look for any indication of the presence of an IED or objects or people that may be related to the placement of an IED (such as straight line in the sand indicating placement of command wire, a pile of rocks, an object used as an aiming point, a disturbance of the soil, a missing populous in a usually full village, a camera being used to photograph patrol or along the road, triggerman).

Step 3.1.1.2.: IF seen, THEN yell, "Stop!"

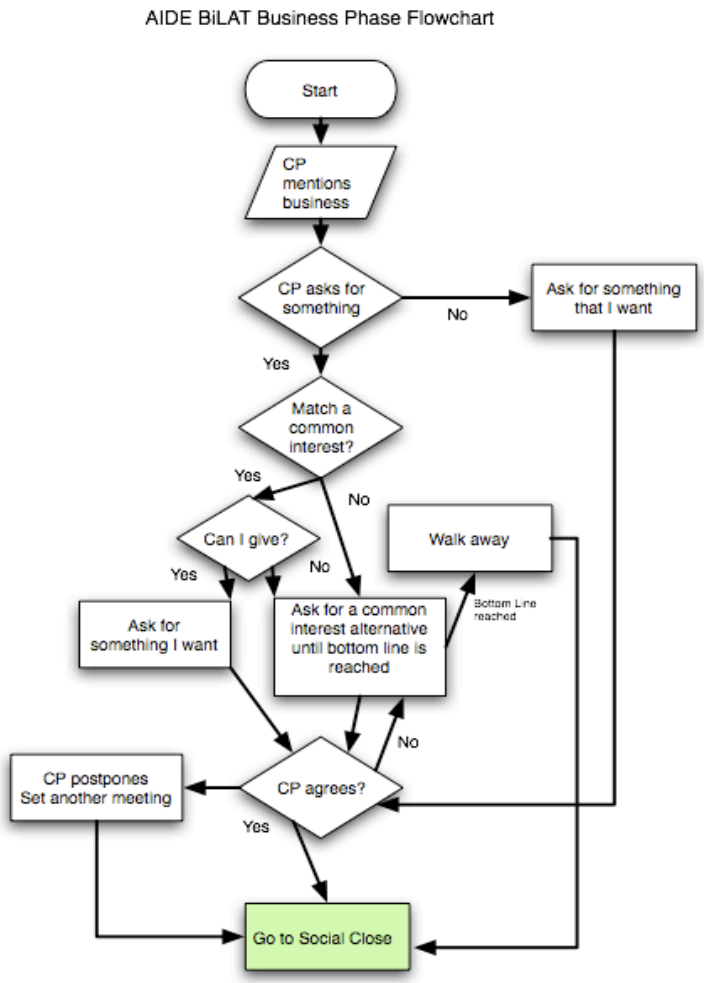
Step 3.1.1.2.: IF threat is heightened due to terrain or other condition and an actual threat is not identified, THEN proceed with dismounts clearing the way for the vehicles.

Step 3.1.2.: IF you find an IED, THEN immediately conduct the Five-C's (confirm, clear, call, cordon, control)

Step 3.1.2.1.: Confirm: The first step when encountering a suspected IED is to confirm that it is an IED. If Soldiers suspect an IED while performing 5 and 25 meter searches of their positions, they should act as if it could detonate at any moment.

Step 3.1.2.2.: Clear: If an IED is confirmed, the next step is to clear the area. The safe distance is determined by several factors: the tactical situation, avoidance of predictability, and movement several hundred meters away

Gold Standard Flow Chart - Negotiating



Using the CTA Results in instruction

- Pull CTA into an instructional design that includes:
  - Performance objectives and reasons
  - References to prior knowledge (analogies, examples)
  - Conceptual knowledge underlying procedure
  - Demonstration of procedure (worked example)
  - Part and Whole task practice on authentic work problems with feedback

Crosswalk of CTA into Instructional Design

CTA Report		Instructional Design
Task Objective	→	Learning objective
Benefits & Risks (Reasons)	→	Reason (benefits & risks)
Main Tasks & Procedures	→	Overview
Prerequisite Skills/Knowledge	→	Prior Knowledge
Concepts, Processes, Principles	→	New Conceptual Knowledge
Action & Decision Steps	→	Demonstration
Problems from SMEs	→	Practice
Checklist from Steps	→	Feedback

Using the CTA Results in Research

- Use CTA to:
  - Capture effective design strategies from experts
    - Empirical studies
    - Blended designs
    - Assessment and measurement
  - Develop the treatments for instructional studies
    - Experimental intervention
    - Simulations
    - Software based on work processes
    - Human factors (human-machine interactions)

References for claims made in workshop

Access our center web page at:

www.cogtech.usc.edu/recent_publications.php

Summaries of research and additional references can be found in the “Cognitive Task Analysis” folder

Give us your feedback!

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